Program Structures & Algorithms
Spring 2022
Assignment No. 4

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➢ Tasks:

- To Implement parallel sorting in order to sort each partition of the array parallely.

- Perform the parallel sorting using different value of cutoff, different values of number of available threads(in power of 2) and then combination of both.

➢ Relationship Conclusion:

- It is observed from the experiment that as the size of array increases, the runtime also increses irrespective of the value of thread and cutoff values.

- Also after one particular value of cutoff, the increase in number of thread value does not make much difference in the performance irrespective of the cutoff value. (Such as runtime for thread value 8,16 and 32 are almost equal.)

- Half the array size is a reasonable cutoff value. A somewhat large (34% * array size) or tiny (14% * array size) cutoff value also works, but not for the considerably larger array size value.

➢ **Supporting Evidence for the conclusion :**

```
Main  ×
C:\Users\DIVYESH\.jdks\openjdk-17.0.2\bin\ja
Degree of parallelism: 2
Array Size: 2000000
cutoff: 1000000     10times Time:4829ms
Degree of parallelism: 4
Array Size: 2000000
cutoff: 1000000     10times Time:3011ms
Degree of parallelism: 8
Array Size: 2000000
cutoff: 1000000     10times Time:2029ms
Degree of parallelism: 16
Array Size: 2000000
cutoff: 1000000     10times Time:2052ms
Degree of parallelism: 32
Array Size: 2000000
cutoff: 1000000     10times Time:2026ms

Degree of parallelism: 2
Array Size: 3000000
cutoff: 1000000     10times Time:5466ms
Degree of parallelism: 4
Array Size: 3000000
cutoff: 1000000     10times Time:4419ms
Degree of parallelism: 8
Array Size: 3000000
cutoff: 1000000     10times Time:3019ms
Degree of parallelism: 16
Array Size: 3000000
cutoff: 1000000     10times Time:3095ms
Degree of parallelism: 32
Array Size: 3000000
cutoff: 1000000     10times Time:3084ms
```

```
Degree of parallelism: 2
Array Size: 4000000
cutoff: 1000000     10times Time:6684ms
Degree of parallelism: 4
Array Size: 4000000
cutoff: 1000000     10times Time:6685ms
Degree of parallelism: 8
Array Size: 4000000
cutoff: 1000000     10times Time:5345ms
Degree of parallelism: 16
Array Size: 4000000
cutoff: 1000000     10times Time:3619ms
Degree of parallelism: 32
Array Size: 4000000
cutoff: 1000000     10times Time:3640ms

Degree of parallelism: 2
Array Size: 5000000
cutoff: 1000000     10times Time:7943ms
Degree of parallelism: 4
Array Size: 5000000
cutoff: 1000000     10times Time:8631ms
Degree of parallelism: 8
Array Size: 5000000
cutoff: 1000000     10times Time:6827ms
Degree of parallelism: 16
Array Size: 5000000
cutoff: 1000000     10times Time:4683ms
Degree of parallelism: 32
Array Size: 5000000
cutoff: 1000000     10times Time:4651ms


Process finished with exit code 0
```

```
C:\Users\DIVYESH\.jdks\openjdk-17.0.2\bin
Degree of parallelism: 2
Array Size: 2000000
cutoff: 1500000      10times Time:4321ms
Degree of parallelism: 4
Array Size: 2000000
cutoff: 1500000      10times Time:2842ms
Degree of parallelism: 8
Array Size: 2000000
cutoff: 1500000      10times Time:2782ms
Degree of parallelism: 16
Array Size: 2000000
cutoff: 1500000      10times Time:2781ms
Degree of parallelism: 32
Array Size: 2000000
cutoff: 1500000      10times Time:2801ms

Degree of parallelism: 2
Array Size: 3000000
cutoff: 1500000      10times Time:5553ms
Degree of parallelism: 4
Array Size: 3000000
cutoff: 1500000      10times Time:4477ms
Degree of parallelism: 8
Array Size: 3000000
cutoff: 1500000      10times Time:3070ms
Degree of parallelism: 16
Array Size: 3000000
cutoff: 1500000      10times Time:3069ms
Degree of parallelism: 32
Array Size: 3000000
cutoff: 1500000      10times Time:3103ms

Degree of parallelism: 2
Array Size: 4000000
cutoff: 1500000      10times Time:7543ms
Degree of parallelism: 4
Array Size: 4000000
cutoff: 1500000      10times Time:6099ms
Degree of parallelism: 8
Array Size: 4000000
cutoff: 1500000      10times Time:4113ms
Degree of parallelism: 16
Array Size: 4000000
cutoff: 1500000      10times Time:4105ms
Degree of parallelism: 32
Array Size: 4000000
cutoff: 1500000      10times Time:4079ms

Degree of parallelism: 2
Array Size: 5000000
cutoff: 1500000      10times Time:10029ms
Degree of parallelism: 4
Array Size: 5000000
cutoff: 1500000      10times Time:7736ms
Degree of parallelism: 8
Array Size: 5000000
cutoff: 1500000      10times Time:5182ms
Degree of parallelism: 16
Array Size: 5000000
cutoff: 1500000      10times Time:5396ms
Degree of parallelism: 32
Array Size: 5000000
cutoff: 1500000      10times Time:5447ms

Process finished with exit code 0
```

```
C:\Users\DIVYESH\.jdks\openjdk-17.0.2\bin
Degree of parallelism: 2
Array Size: 2000000
cutoff: 2000000      10times Time:4011ms
Degree of parallelism: 4
Array Size: 2000000
cutoff: 2000000      10times Time:2824ms
Degree of parallelism: 8
Array Size: 2000000
cutoff: 2000000      10times Time:2718ms
Degree of parallelism: 16
Array Size: 2000000
cutoff: 2000000      10times Time:2724ms
Degree of parallelism: 32
Array Size: 2000000
cutoff: 2000000      10times Time:2744ms

Degree of parallelism: 2
Array Size: 3000000
cutoff: 2000000      10times Time:4182ms
Degree of parallelism: 4
Array Size: 3000000
cutoff: 2000000      10times Time:4133ms
Degree of parallelism: 8
Array Size: 3000000
cutoff: 2000000      10times Time:4180ms
Degree of parallelism: 16
Array Size: 3000000
cutoff: 2000000      10times Time:4159ms
Degree of parallelism: 32
Array Size: 3000000
cutoff: 2000000      10times Time:4138ms

Degree of parallelism: 2

Degree of parallelism: 2
Array Size: 4000000
cutoff: 2000000      10times Time:7403ms
Degree of parallelism: 4
Array Size: 4000000
cutoff: 2000000      10times Time:5939ms
Degree of parallelism: 8
Array Size: 4000000
cutoff: 2000000      10times Time:4067ms
Degree of parallelism: 16
Array Size: 4000000
cutoff: 2000000      10times Time:4088ms
Degree of parallelism: 32
Array Size: 4000000
cutoff: 2000000      10times Time:3988ms

Degree of parallelism: 2
Array Size: 5000000
cutoff: 2000000      10times Time:9229ms
Degree of parallelism: 4
Array Size: 5000000
cutoff: 2000000      10times Time:7742ms
Degree of parallelism: 8
Array Size: 5000000
cutoff: 2000000      10times Time:4955ms
Degree of parallelism: 16
Array Size: 5000000
cutoff: 2000000      10times Time:5012ms
Degree of parallelism: 32
Array Size: 5000000
cutoff: 2000000      10times Time:5077ms


Process finished with exit code 0
```

```
C:\Users\DIVYESH\.jdks\openjdk-17.0.2\bin
Degree of parallelism: 2
Array Size: 2000000
cutoff: 2500000      10times Time:4937ms
Degree of parallelism: 4
Array Size: 2000000
cutoff: 2500000      10times Time:3811ms
Degree of parallelism: 8
Array Size: 2000000
cutoff: 2500000      10times Time:3749ms
Degree of parallelism: 16
Array Size: 2000000
cutoff: 2500000      10times Time:3686ms
Degree of parallelism: 32
Array Size: 2000000
cutoff: 2500000      10times Time:3749ms

Degree of parallelism: 2
Array Size: 3000000
cutoff: 2500000      10times Time:4468ms
Degree of parallelism: 4
Array Size: 3000000
cutoff: 2500000      10times Time:4124ms
Degree of parallelism: 8
Array Size: 3000000
cutoff: 2500000      10times Time:4140ms
Degree of parallelism: 16
Array Size: 3000000
cutoff: 2500000      10times Time:4139ms
Degree of parallelism: 32
Array Size: 3000000
cutoff: 2500000      10times Time:4140ms


Degree of parallelism: 2
Array Size: 4000000
cutoff: 2500000      10times Time:5625ms
Degree of parallelism: 4
Array Size: 4000000
cutoff: 2500000      10times Time:5578ms
Degree of parallelism: 8
Array Size: 4000000
cutoff: 2500000      10times Time:5546ms
Degree of parallelism: 16
Array Size: 4000000
cutoff: 2500000      10times Time:5571ms
Degree of parallelism: 32
Array Size: 4000000
cutoff: 2500000      10times Time:5593ms

Degree of parallelism: 2
Array Size: 5000000
cutoff: 2500000      10times Time:9155ms
Degree of parallelism: 4
Array Size: 5000000
cutoff: 2500000      10times Time:7543ms
Degree of parallelism: 8
Array Size: 5000000
cutoff: 2500000      10times Time:5015ms
Degree of parallelism: 16
Array Size: 5000000
cutoff: 2500000      10times Time:5109ms
Degree of parallelism: 32
Array Size: 5000000
cutoff: 2500000      10times Time:4983ms


Process finished with exit code 0
```
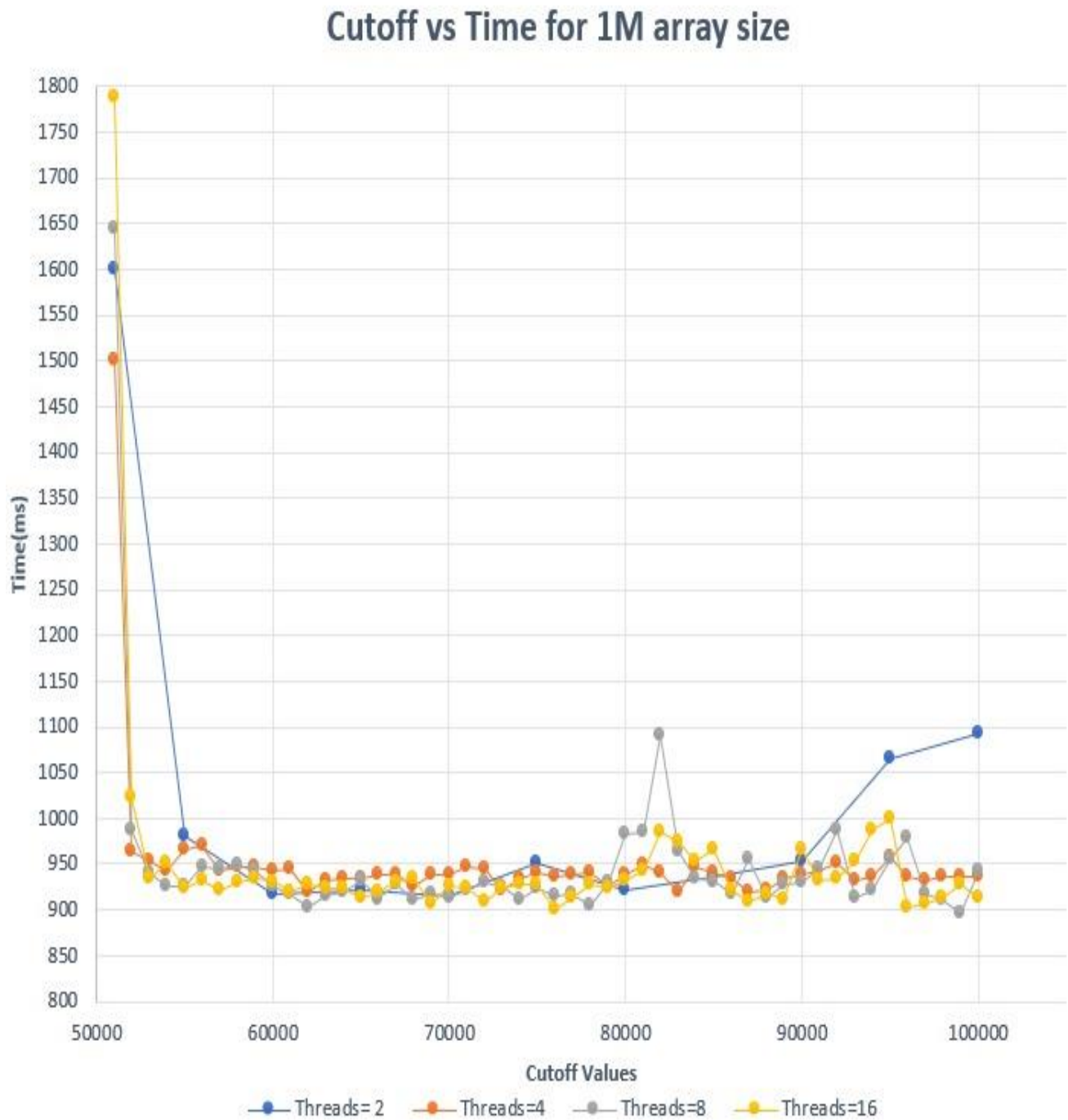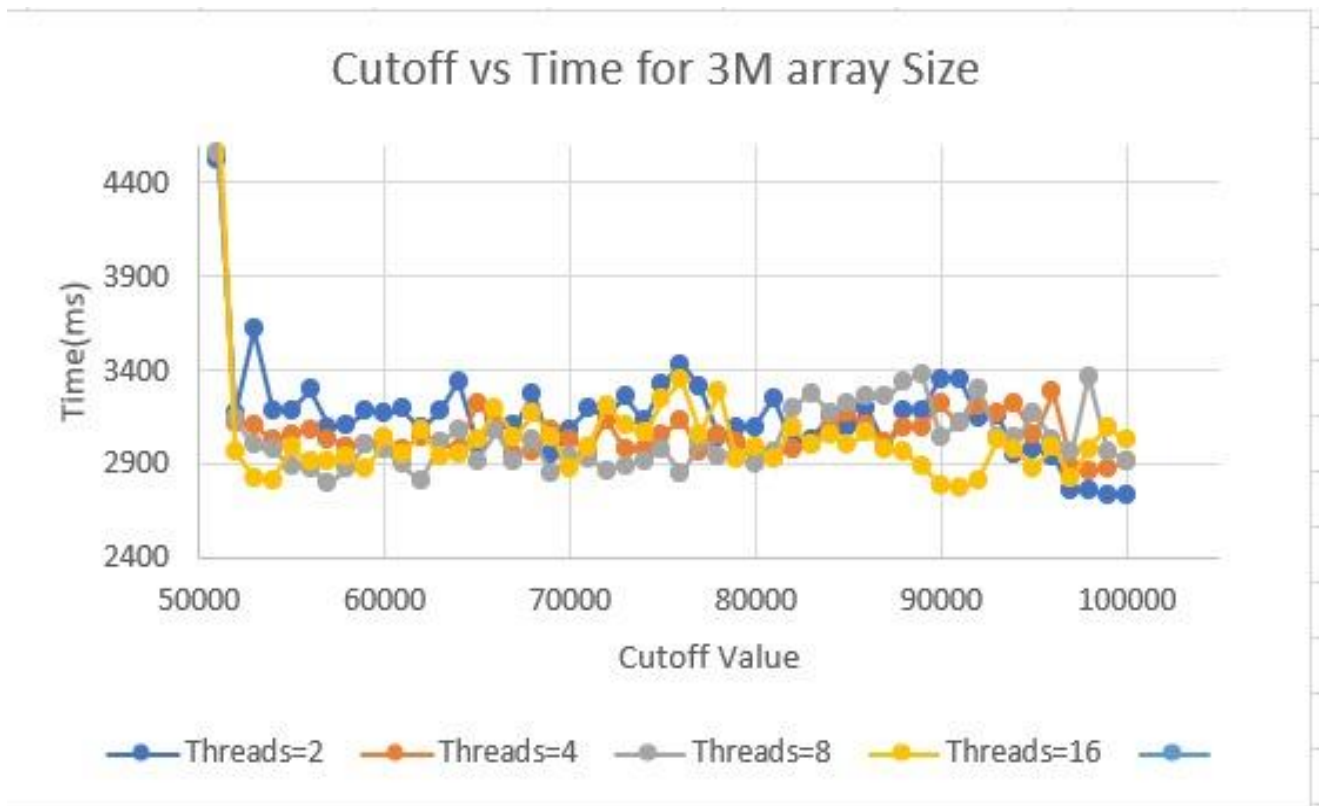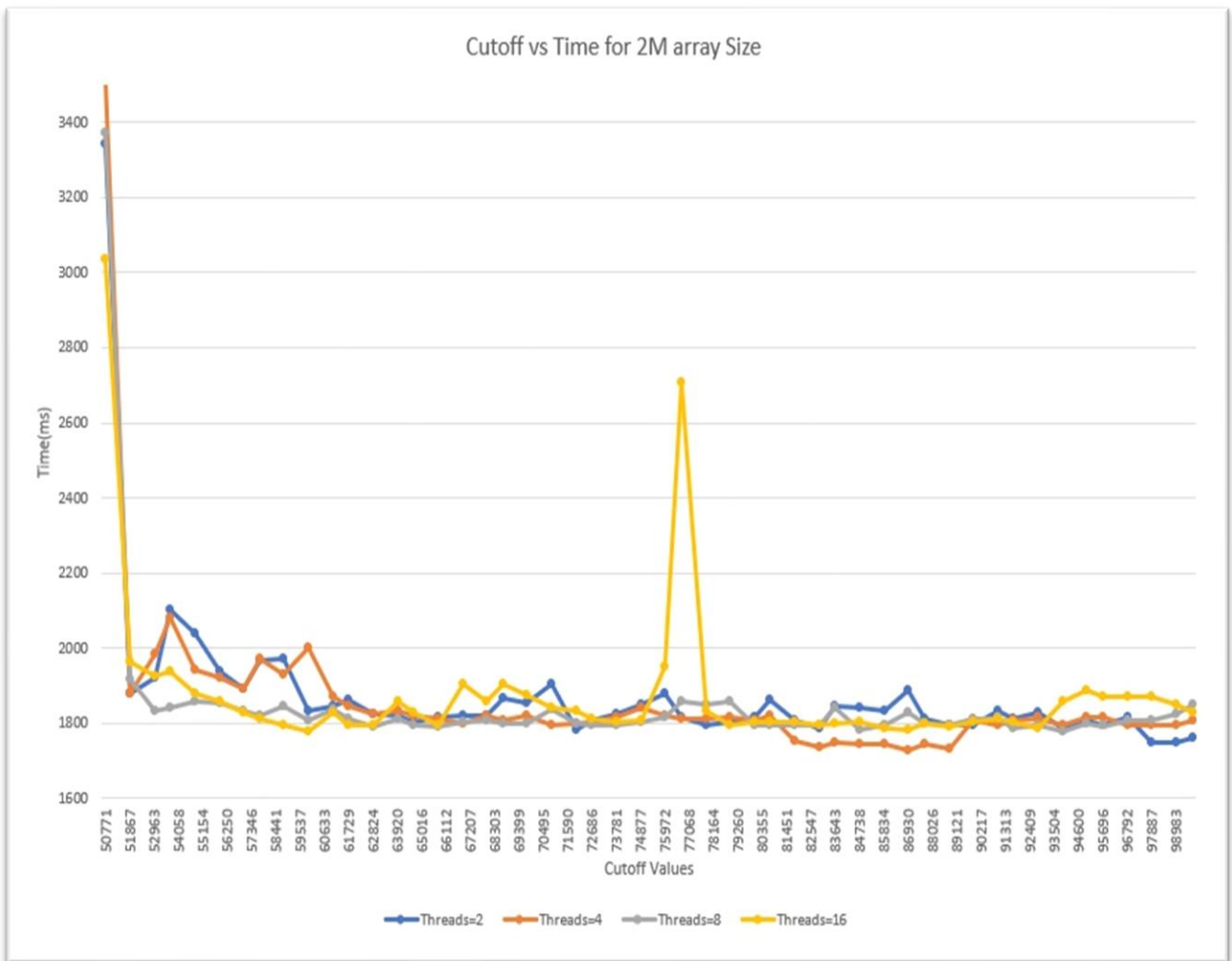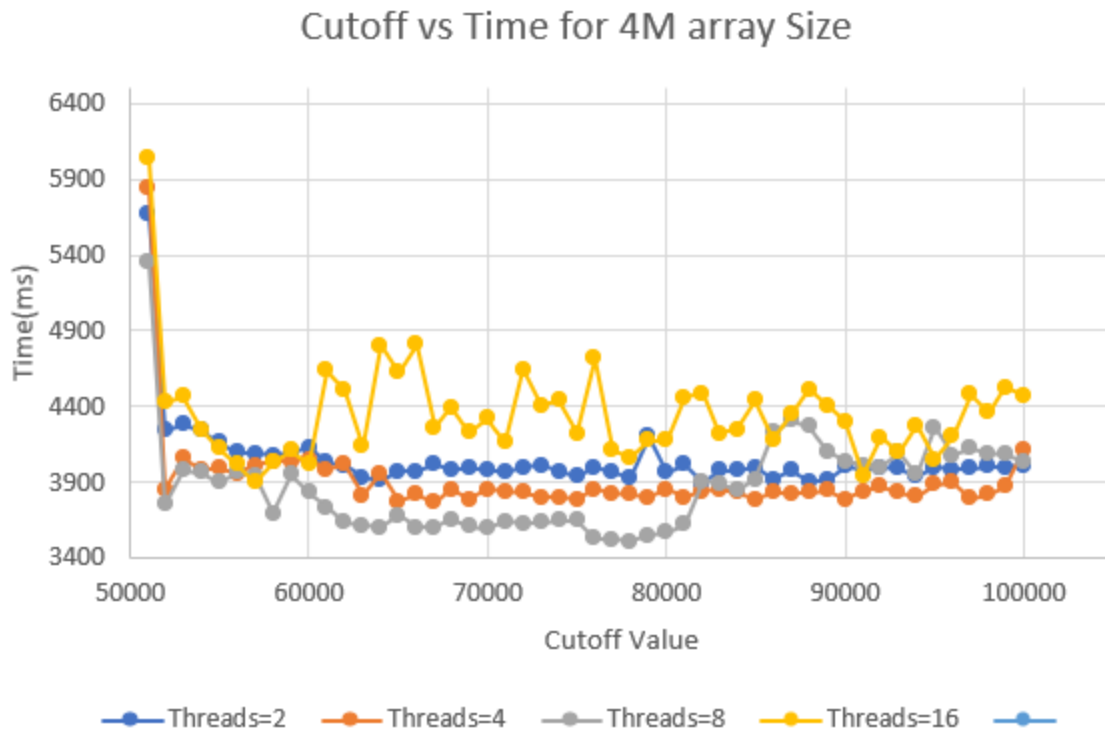
➢ Graphical Representation:

Cutoff vs Time for 1M array size

Cutoff vs Time for 2M array Size

Cutoff vs Time for 3M array Size

Cutoff vs Time for 4M array Size

Chart: Cutoff vs Time for 4M array Size. Y-axis: Time(ms) ranging from 3400 to 6400. X-axis: Cutoff Value ranging from 50000 to 100000. Legend: Threads=2, Threads=4, Threads=8, Threads=16.

➢ **Conclusion**

- It is observed the combination of cutoff value equal to half the size of array and number of threads equal to 8 make a really good combination for relatively large sized array. Taking extremely large or very small value of cutoff don't yield better for relatively large sized array which is depicted from the screenshots of output and the plots.